

**Applicant: Eesley et al.**  
**Serial No.: 09/804,756**  
**Reply to Office action of 12/31/2003**

This listing of claims will replace all prior versions, and listings, of claims in the application.

**LISTING OF CLAIMS:**

Claim 1 (Canceled)

2. (Previously Presented) A heat sink of claim 22 wherein said fins and said foam blocks are connected to one surface of said heat spreader plate.

3. (Currently amended) A heat sink for electrical or electronic components comprising:

a heat spreader plate to which the components to be cooled are connected;  
at least two heat conducting fins that are positioned substantially parallel to one another and which are connected substantially perpendicular to said heat spreader plate;

at least one foam block that is disposed in the space between parallel fins wherein said block is formed of reticulated foam to define a highly porous, heat conducting, open-celled structure that permits a cooling fluid to flow through said block as the cooling fluid passes across said fins; and

said at least one foam block being made from aluminum, copper, graphite, or aluminum-nitride ceramic ~~A heat sink of claim 1~~

wherein the fin height, **b**, is determined by the relationship,

$$b = 0.6498 \sqrt{\frac{k_f \delta_f}{h}}$$

where,

$k_f$  is the thermal conductivity of the selected fin material, Btu/ft s °F

$\delta_f$  is the fin thickness, ft

$h$  is the convective heat transfer coefficient for the foam-filled space bounded by said fins and said heat spreader plate, Btu/ft<sup>2</sup> s °F, and where  $h$  is given by the formula,

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$$h = 1.2704 \left[ \frac{n^{0.50}}{(1 - \phi)^{0.25}} \right] \left( \frac{\rho^{0.50} k^{0.63} c_p^{0.37}}{\mu^{0.13}} \right) u_m^{0.50}$$

where,

$n$  is the linear density of said at least one foam block, pores per ft

$\phi$  is the porosity of said at least one foam block, expressed as a fraction

$\rho$  is the density of the cooling fluid that passes across said fins,  $\text{lb}_m/\text{ft}^3$

$k$  is the thermal conductivity of the cooling fluid,  $\text{Btu}/\text{ft s } ^\circ\text{F}$

$c_p$  is the isobaric specific heat of the cooling fluid,  $\text{Btu}/\text{lb}_m ^\circ\text{F}$

$\mu$  is the dynamic viscosity of the cooling fluid,  $\text{lb}_m/\text{ft s}$

$u_m$  is the mean velocity of the cooling fluid,  $\text{ft/s}$

4. **(Currently amended)** A heat sink for electrical or electronic components comprising:

a heat spreader plate to which the components to be cooled are connected;

at least two heat conducting fins that are positioned substantially parallel to one another and which are connected substantially perpendicular to said heat spreader plate;

at least one foam block that is disposed in the space between parallel fins wherein said block is formed of reticulated foam to define a highly porous, heat conducting, open-celled structure that permits a cooling fluid to flow through said block as the cooling fluid passes across said fins; and

said at least one foam block being made from aluminum, copper, graphite, or aluminum-nitride ceramic ~~A heat sink of claim 1~~

wherein the fin spacing,  $a$ , is determined by the relationship,

$$a = \Phi \delta$$

where,

$\Phi$  is between 1 to 6

$\delta$ , ft, is determined by the relation,

$$\delta = 7.32 \sqrt{\frac{kc}{\rho c_p u_m}}$$

where,

$c$  is the selected fin length in the flow direction, ft

$k$  is the thermal conductivity of the cooling fluid that passes across said fins,  
Btu/ft s °F

$\rho$  is the density of the cooling fluid lb<sub>m</sub>/ft<sup>3</sup>

$c_p$  is the isobaric specific heat of the cooling fluid, Btu/lb<sub>m</sub>°F

$u_m$  is the mean velocity of the cooling fluid, ft/s.

5. **(Currently amended)** A heat sink of claim [[1]] 3 wherein said heat spreader plate, said fins and said at least one foam block are made from the same or different thermal conducting materials.

6. **(Currently amended)** A heat sink of claim [[1]] 3 wherein said heat spreader plate and said fins are made from aluminum, copper, graphite or aluminum-nitride ceramic.

7. **(Currently Amended)** A heat sink of claim [[1]] 3 wherein said heat spreader plate and said fins are made from aluminum.

Claims 8 – 20: **(Cancelled)**

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21.     **(Currently amended)**     A heat sink of claim ~~[[1]]~~ 3 wherein said fins and said at least one foam block are connected to one surface of said heat spreader plate.

22.     **(Currently amended)**     A heat sink of claim ~~[[1]]~~ 3 wherein said at least one foam block is further defined as a plurality of foam blocks.

23.     **(Previously presented)**     A heat sink of claim 22 wherein said fins are connected to said heat spreader plate through thermal bonding.

24.     **(Previously presented)**     A heat sink of claim 22 wherein said fins are connected to said foam blocks through thermal bonding.

25.     **(Previously presented)**     A heat sink of claim 23 wherein said fins are connected to said foam blocks through thermal bonding.

26.     **(Currently amended)**     A heat sink of claim ~~[[1]]~~ 3 wherein said fins are connected to said heat spreader plate through thermal bonding.

27.     **(Currently amended)**     A heat sink of claim ~~[[1]]~~ 3 wherein said fins are connected to said at least one foam block through thermal bonding.

28.     **(Previously presented)**     A heat sink of claim 26 wherein said fins are connected to said at least one foam block through thermal bonding.

29. (New) A heat sink for electrical or electronic components comprising:
- a heat spreader plate to which the components to be cooled are connected;
- at least two heat conducting fins that are positioned substantially parallel to one another and which are connected substantially perpendicular to said heat spreader plate;
- at least one foam block that is disposed in the space between parallel fins wherein said block is formed of reticulated foam to define a highly porous, heat conducting, open-celled structure that permits a cooling fluid to flow through said block as the cooling fluid passes across said fins; and
- said at least one foam block being made from aluminum, copper, graphite, or aluminum-nitride ceramic,
- wherein the fin height, **b**, is determined by the relationship, and

$$b = 0.6498 \sqrt{\frac{k_f \delta_f}{h}}$$

where,

$k_f$  is the thermal conductivity of the selected fin material, Btu/ft s °F

$\delta_f$  is the fin thickness, ft

$h$  is the convective heat transfer coefficient for the foam-filled space bounded by said fins and said heat spreader plate, Btu/ft<sup>2</sup> s °F, and where  $h$  is given by the formula,

$$h = 1.2704 \left[ \frac{n^{0.50}}{(1 - \phi)^{0.25}} \right] \left( \frac{\rho^{0.50} k^{0.63} c_p^{0.37}}{\mu^{0.13}} \right) u_m^{0.50}$$

where,

$n$  is the linear density of said at least one foam block, pores per ft

$\phi$  is the porosity of said at least one foam block, expressed as a fraction

$\rho$  is the density of the cooling fluid that passes across said fins,  $\text{lb}_m/\text{ft}^3$

$k$  is the thermal conductivity of the cooling fluid,  $\text{Btu}/\text{ft s } ^\circ\text{F}$

$c_p$  is the isobaric specific heat of the cooling fluid,  $\text{Btu}/\text{lb}_m ^\circ\text{F}$

$\mu$  is the dynamic viscosity of the cooling fluid,  $\text{lb}_m/\text{ft s}$

$u_m$  is the mean velocity of the cooling fluid,  $\text{ft/s}$  and

a heat spreader plate to which the components to be cooled are connected;

at least two heat conducting fins that are positioned substantially parallel to one another and which are connected substantially perpendicular to said heat spreader plate;

at least one foam block that is disposed in the space between parallel fins wherein said block is formed of reticulated foam to define a highly porous, heat conducting, open-celled structure that permits a cooling fluid to flow through said block as the cooling fluid passes across said fins; and

said at least one foam block being made from aluminum, copper, graphite, or aluminum-nitride ceramic ~~A heat sink of claim 1~~

wherein the fin spacing,  $a$ , is determined by the relationship,

$$a = \Phi \delta$$

where,

$\Phi$  is between 1 to 6

$\delta$ , ft, is determined by the relation,

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$$\delta = 7.32 \sqrt{\frac{kc}{\rho c_p u_m}}$$

where,

**c** is the selected fin length in the flow direction, ft

**k** is the thermal conductivity of the cooling fluid that passes across said fins, Btu/ft s oF

**ρ** is the density of the cooling fluid lbm/ft<sup>3</sup>

**c<sub>p</sub>** is the isobaric specific heat of the cooling fluid, Btu/lbm oF

**u<sub>m</sub>** is the mean velocity of the cooling fluid, ft/s.